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ARTICLE

Diversity and Biomass of Understory Plants in *Larix gmelinii* Forest under Different Reconstruction Methods

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ABSTRACT

The effects of different management measures on the undergrowth diversity of Larix gmelinii forests were determined. The undergrowth vegetation of Xing'an Larch forest under seven different transformation methods was investigated in the Chaocha Forest Farm of the Genhe Forestry Bureau in the northern Daxinganling Mountains. Community composition, structural characteristics, species diversity and biomass of seven different retrofitting methods and one control plot. The results showed that the species composition of Larix gmeliniii under 7 different transformation methods included 34 species of 30 genera and 21 families of shrubs, including 7 species, 7 genera and 7 species of shrub layer, and 20 species, 24 genera and 24 species of common species in the herb layer. The species with the largest proportion in the layer is bilberry, followed by Xing'an rhododendron, and the dominant species of herbaceous layer is quite different. In terms of diversity index, the diversity index of Xing'an larch forest under local tending artificial promotion natural regeneration and transformation measures was low ($P<0.05$); the study showed that the best tending thinning intensity was between 30% and 40%, different. The impact of the transformation method on the structure and diversity of understory vegetation in Larix gmelinii forest is not only related to the transformation, but also depends on the transformation measures taken.

1. Introduction

Dahurian larch (Larix gmelinii (Rupr.) Rupr.) forests are mainly distributed in northeastern Asia. Due to long-term over-utilization and poor protection, the Daxinganling natural forest has changed its original structure and function, and lost its natural regularity. Therefore, it is necessary to optimize the structure with different management measures to improve the stability of the ecosystem. Baskin [1] showed in the experiment that the increase of species diversity can improve the stability of the ecosystem.And the same results were obtained in the study of forest communities [2-4].Species diversity is a manifestation of biodiversity at the species level, which can characterize the structural complexity of a biome, reflecting the structural type, organization level, development stage, stability level and habitat level of the community. It is a biodiversity. The important organic component is the research hotspot in the field of ecology [5]. At the same time, the restoration of species diversity is also one of the most important features in the process of vegetation restoration [6]. Our the biomass,

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diversity and structure of understory vegetation to reflect the effects of the transformation measures.

1.1 Overview of the Study Area

The test site is located in the experimental area of the National Wildlife Science Research Station, located in the Greater Xing'an Mountains Ecosystem in Inner Mongolia, in the Chaocha Forest Farm of the Genhe Forestry Bureau in the northern part of Daxing'anling. It is a typical cold temperate northern forest area. The highest altitude is 1199 m, the annual average temperature is -5.0℃ , the annual average precipitation is 400-500mm, the frost-free period is 80-90 days, and the annual effective accumulated temperature of ≥10 ℃ is 1308.9 ℃ .The zonal soil is brown coniferous forest soil, grey forest soil, black calcium soil, the bedrock is mainly granite and basalt, the thickness of soil layer is 5 ~ 40 cm, there are continuous permafrost and island permafrost staggered distribution in this area.There are 363 species belonging to 212 genera and 74 families in this area. L. gmelinii forest is a cold temperate coniferous forest dominated (?)_by Larix gmelinii. Associated tree species include Betula platyphylla Suk. and Populus davidiana Dode., and characteristic understory species include Ledum palustre L., Rhododendron dauricum L., Vaccinium uliginosum Linn., Pyrola incarnata Fisch. ex DC.

1.2 Research Methods

1.2.1 Design of Different Renovation Measures

Seven fixed sample plots were set up in L. gmelinii and B. platyphylla communities in 2012. Each plot was subjected to a different treatment. The first plot was managed to artificially promote the update. A 1 m^2 small quadrant was set up to remove shrubs and herbs in the small quadrant, throw away dead cover layer (dry branches and fallen leaves), expose the surface layer of soil, improve the probability of seed contact with soil, promote seed rooting and germination, and promote natural regeneration of stand. The second plot was managed to promote mixed forest. 1 to 2 B. platyphylla with straight trunk shape, full crown and good growth should be kept in each cluster. 2-year-old L. gmelinii seedlings with needle insertion were planted in the gap of the sample plot and a density of 2490 plants/hm^2, and 398 B. platyphylla were planted in the sample plot. The third plot was tending and thinning: thinning the cluster Betula platyphylla in the sample plot. The thinning objects are birch grade 4 and 5 trees, upper trees with diameter over 14 cm and overlord trees. Cutting volume intensity was 30%, and plant number intensity was 59%. The fourth plot was tending and intermittent cutting of forest:thinning the cluster birch in the sample plot, keeping 1-2 Betula platyphylla with straight trunk shape, full crown and good growth in each cluster. Cutting down dead trees, P. davidiana Dode and other non-target species, as well as the overlord trees with diameter over 19 cm at breast height of B. platyphylla. Cutting volume intensity was 20%, and number intensity was 13%. Ⅴ . Local nurturing artificially promotes regeneration: Intermediate cutting of Cluster B. platyphylla in sample plot showed that the cutting volume intensity was 15% and the number intensity was 45%. Setting up a 1 m^2 small sample, clearing shrubs and herbs in the small sample, throwing away dead cover layer (dry branches and fallen

Table 1.Existing forest conditions after different transformation methods

Standard place number	Basic situation of forest stand	Business conditions	Existing forest	
			Density/strain·hm^{-2}	Average breast diameter / cm
I	——————	Manual promotion of renewal by abandoning ground cover in 2012	2488	11.6
II	Survival rate of supplementary seedling 77%	Mixed forest was induced by replanting Larch Seedlings in 2012	2781	7.6
III	——————	30% thinning intensity in 2012	2925	10
IV	——————	20% thinning intensity in 2012	4375	10.9
V	——————	Artificial Removal of Ground Cover to Promote Renewal after Local Care in 2012	1106	11.8
VI	——————	40% thinning intensity in 2012	4325	7.7
VII	——————	10% thinning intensity in 2012	2725	10.6
VIII	——————	Through natural sparseness to retain trees, do not operate.	2925	10

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leaves), exposing the surface layer of soil, improving the probability of seed contact with soil, promoting seed rooting and germination, and promoting natural regeneration of stand. The sixth plot was treated by intermittent cutting of forest. Young trees and grade 5 trees of B. platyphylla were felled and regenerated. Thinning dead trees, P. davidiana Dode and other non-target species, as well as the upper layer of Betula platyphylla whose DBH is more than 14 cm. Cut down the upper layer and some 4-5 grade trees of L. gmelinii whose DBH is more than 14 cm. Cutting volume intensity was 40%, and plant number intensity was 50%. The seventh plot was treated by cutting down dead trees of P. davidiana Dode and B. platyphylla to regenerate young trees and Betula platyphylla overlord trees in the sample plot. Cutting volume intensity was 10% and plant number intensity was 18%. The eight plot acted as a control. The following is a picture of the existing forest land after management and transformation (Table 1.)

1.2.2 Biomass survey

The arbor biomass [7] of L. gmelinii was determined using the equation: $W=0.1359\ D^{2.4077}$, $R^2=0.983$. The arbor biomass of B. platyphylla was determined using the equation: $W=0.02853(D^2H)0.89278+0.00278(D^2H)^{1.02568}+0.01545(D^2H)^{0.61265}+0.023923\ (D^2H)^{0.69612}$

The biomasses of the shrub and herb layers were measured using a quadrate harvesting method [8,9]. The species and quantity of shrubs and herbaceous plants were registered. The area of the shrub layer was 2 m^2. The aboveground biomass was measured. The area of herbaceous layer was 1 m^2. The aboveground biomass was measured. The litter biomass was investigated together with the biomass of shrubs and herbaceous layer in the same layer.

1.2.3 Plant Diversity Analysis

Eight plots were determined. Five plots were set in each plot. Density (plant/m^2), average crown width (m^2/plant), coverage (%, that is, the ratio of the total elliptic area of all tree crowns to the area occupied by the ground), average breast diameter (cm/plant), average height (m/plant), aboveground biomass[10-16] were measured to calculate community diversity.Diversity measures include:

(1) Richness:

$$R=(S-1)/Ln(N)$$

Among them, S is the number of species in the community, A is the total number of individuals observed.

(2) Shannon-Wiener diversity index:

$$H'=-\sum_{i=1}^{s} PiLnPi$$

(3) Pielou index of uniformity:

$$J=H'/LnS$$

(4) Simpson diversity index:

$$D=1-\sum_{i=1}^{S} Pi^2$$

S is the total number of species in the community, Pi is the proportion of species I in the total number of individuals in the community, that is, Pi = Ni / N, Ni is the number of species i, and N is the total number of observed individuals.

Important value = (relative frequency + relative abundance + relative coverage) / 3

2. Results and Analysis

2.1 Species Composition and Important Values

There are 34 species belonging to 30 genera and 21 families, including 7 species belonging to 7 genera and 3 families of shrubs and 24 species belonging to 24 genera and 20 families of herbs.

Shrub layer: According to the statistics in the table below, there are three species of shrubs: Vaccinium vitis-idaea Linn., Rhododendron dauricum L., Rosa bella Rehd. The endemic species is Salix raddeana Laksch. ex Nas. Only 5 plots have a single species. Vaccinium vitis-idaea Linn., followed by Rhododendron dauricum L. and Rosa Bella Rehd; Vaccinium vitis-idaea Linn., followed by Rhododendron dauricum L. and Rosa Bella Rehd; Vaccinium vitis-ida Linn., followed by Rhododendron dauricum L. and Rosa Bella Rehd; Vaccinium vitis-ida Linn., followed by Rhododendron L. and Rosa Bella Rehd; and 4. The most important values were Vaccinium vitis-idaea Linn., followed by Rhododendron dauricum L. and Rosa Bella Rehd; Vaccinium vitis-idaea Linn. for plot 5, followed by Spiraea salicifolia L. and Rhododendron dauricum L. for plots 6, 7 and 8, Vaccinium vitis-idaea Linn. was the most important value, followed by Rhododendron dauricum L. and Rosa Bella Rehd. The majority of common species indicates that the dominant species are comparatively similar [17].

Herbaceous layer: The most important value of sample 1 was Deyeuxia langsdorff II (L ink) kunth., followed by Rubia cordifolia L. and Maaianthemum bifolium (L.) F. W. Schmidt; the most important value of sample 2 was Rubia cordifo L., followed by Fragaria orientalis insk and Deye-langsdorff (L ink) Kunth ii.; and the most important value of sample 3 was Deyeuxia langsdorff (L ink) Kunth ii. The second is Rubia cordifolia L. and Trientalis europaea; the maximum value of the four plots is Deyeuxia langsdorff II (L

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Table 2. The important valves of common species and single species in the shrub layer

No.	Species	Important valves(%)								Common species/Single species
		I	II	III	IV	V	VI	VII	VIII	
1	Vaccinium vitis-idaea Linn.	42.70	29.79	29.82	35.97	20.13	50.22	43.62	37.18	Common species
2	Rhododendron dauricum L.	22.10	29.14	28.94	25.07	14.18	12.57	18.96	35.90	
3	Rosa bella Rehd	12.80	8.83	25.14	5.09	9.49	4.43	11.80	5.00	
4	Spiraea salicifolia L.	14.00	6.91	4.67	0.83	14.81		3.80		
5	Ribes nigrum L.	1.70	2.08		2.05	10.01			2.80	
6	Sorbaria sorbifolia (L.) A. Br		4.56			4.26		0.90		
7	Ledum palustre L.				11.20		11.30		4.00	
8	Rubus corchorifolius L.f.	5.90		7.70						
9	Salix raddeana Laksch. ex Nas.					2.40				Single species

ink) kunth.; the second is Maianthemum bifolium (L.) F. W. Schmidt and Rubia cordifo L.; the fifth plot is Fragaria cordifolia L. Losinsk, the second is Deyeuxia langsdorff (L) kunthlia L.; the sixth plot is the most important value. Fragaria orientalis Losinsk was the largest, followed by Deyeuxia langsdorff II (L ink) kunth. and Rubia cordifolia L.; Linnaea Borealis L., followed by Maianthemum bifolium (L.), F. W. Schmidt and Rubia cordifolia L., and Deyeuxia langsdorff II (L ink) kunth. The largest, followed by Vicnasepium and Linnaborealis L., as a control. The maximum value of area 8 was Linnaea Borealis L., followed by Maianthemum bifolium (L.) F. W. Schmidt and Rubia cordifolia L.

2.2 Diversity of Shrubs and Herbs under Different Transformation Methods

Simpson index reflects the concentration of the whole community. Shrub layer: Simpson index of sample 6 in 2012 is basically the same as that in 2017, and has little change. Simpson index of sample 5 in 2017 is lower than that in 2012, which differs greatly from other transformation measures. Simpson index of other sample sites in 2017 is higher than that in 2017; Shannon-Wiener index of sample 6 has little change compared with that in 2012, and Shannon-Wiener index of sample 5 has little change in 2012. The on-Wiener index is lower than that in 2017, which is quite different from other reformation measures. The overall change trend of Shannon-Wiener index and Simpson index is similar after five years reformation;The richness index of No. 2 plot and No. 4 plot remained basically unchanged. The richness index of No. 5 and No. 6 plot was lower than that of the revamped plot in 2012. Unlike other plots, the richness index of the other plots in 2017 was higher than that of 2017; the evenness index of No. 2 plot and No. 4 plot basically changed little, the values of No. 5 and No. 6 plots were lower than that of the revamped plot in 2012, and the evenness index of other plots in 201 After 5 years improvement, the overall change trend of richness index and evenness index is similar.

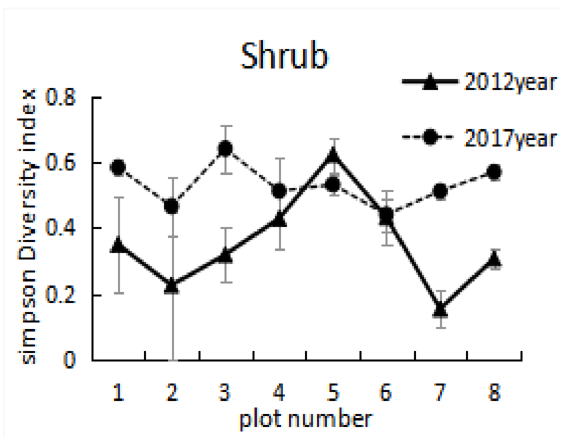

Figure 1. Two-year shrub Simpson

Table 3. Common species of herbaceous layer and a single important value

No.	Species	Important valves(%)								Common species/Single species
		I	II	III	IV	V	VI	VII	VIII	
1	Linnaea borealis L.	1.21	0.23	6.68	4.80	3.69	19.81	2.35	35.24	Common species
2	Deyeuxia langsdorffii (L ink)kunth.	36.28	6.63	38.77	18.02	15.41	3.76	11.70	8.83	
3	Fragaria orientalis Losinsk	4.43	8.77	7.90	0.41	24.74	1.74	1.19	0.38	
4	Trientalis europaea	3.81	3.44	9.27	1.67	4.16	0.55	0.16	0.55	
5	Rubia cordifolia L.	26.55	8.78	12.94	5.39	14.70	6.84	0.27	6.84	
6	Maianthemum bifolium (L.) F. W. Schmidt	10.99	4.44	2.65	5.98	3.83	18.88	7.92	11.52	
7	Vicia sepium	5.13	0.67	0.75	0.56	0.13	1.28	3.46	1.27	
8	Adina rubella Hance	0.76								Single species
9	Convallaria majalis Linn.		2.28							Single species
10	Paris verticillata M. Bieb.					0.90				Single species
11	Adenophora tricuspidata (Fisch. ex Roem. et Schult.) A. DC.					3.50				Single species
12	Potentilla chinensis Ser.							0.60		Single species
13	Anemone dichotoma L.								0.29	Single species
14	Anemone cathayensis Kitag								0.29	Single species
15	Artemisia tanacetifolia Linn.								0.25	Single species

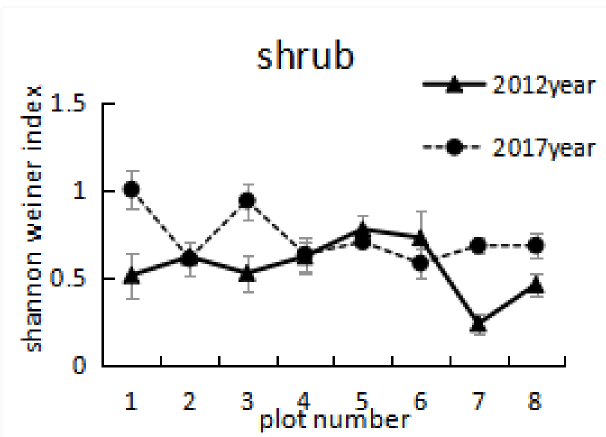

Figure2. Two-year shrub Shannon-Wiener index comparison index comparison

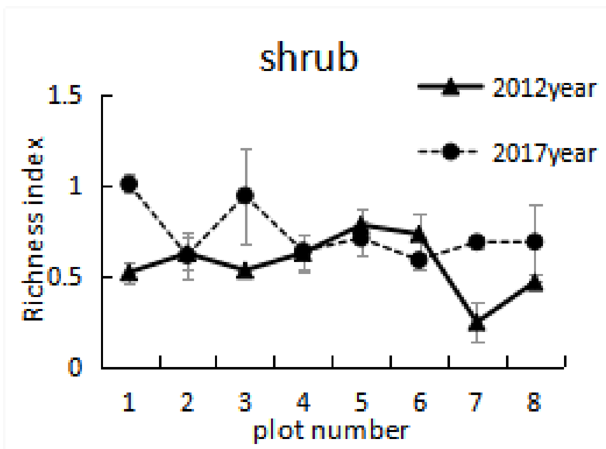

Figure 3. Two-year shrub richness

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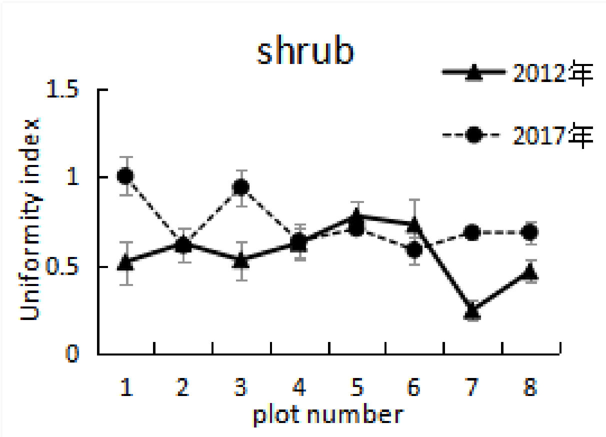

Figure 4. Two-year shrub uniformity index comparison index comparison

Herbaceous layer: Simpson index of sample 3 remained unchanged, Simpson index of sample 1 and 8 was lower than that of 2012 in 2017, Simpson index of other sample plots increased greatly in 2017; Shannon-Wiener index of sample 3 remained unchanged, Shannon-Wiener index of sample 1 and 8 were lower than that of 2012, Shannon-Wiener index of other sample plots increased in 2017; richness index of sample 4 was lower than that of 2012. Low, the richness index of No. 1, 2 and 5 plots has increased significantly, the richness index of No. 3, 6, 7 and 8 plots has a smaller growth than that of 2012, the evenness index of No. 4 plots has decreased compared with 2012, the evenness index of No. 1, 2 and 5 plots has greatly increased, the evenness index of No. 3, 6, 7 and 8 plots has a smaller growth than that of 2012, and the increasing trend of richness index is similar to that of evenness index.

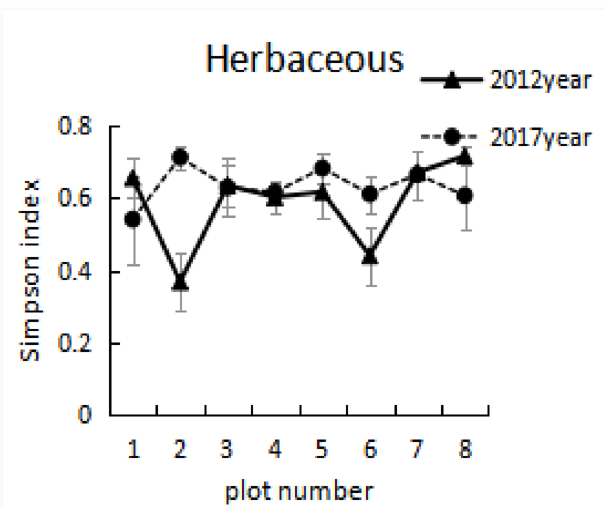

Figure 4. Two-year herbal Simpson

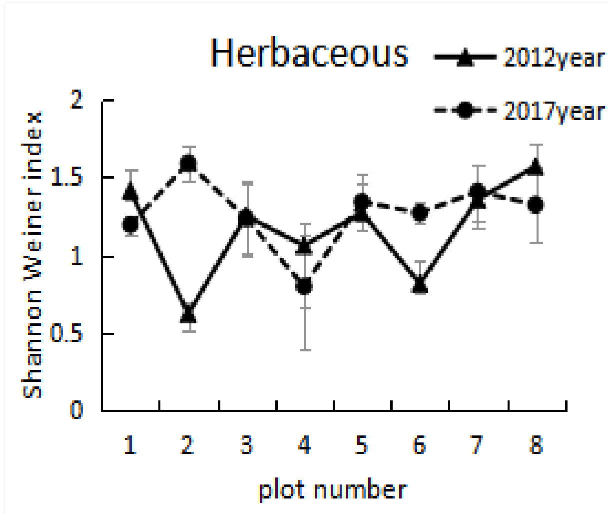

Figure 5. Two-year herbal Shannon-Wiener index comparison index comparison

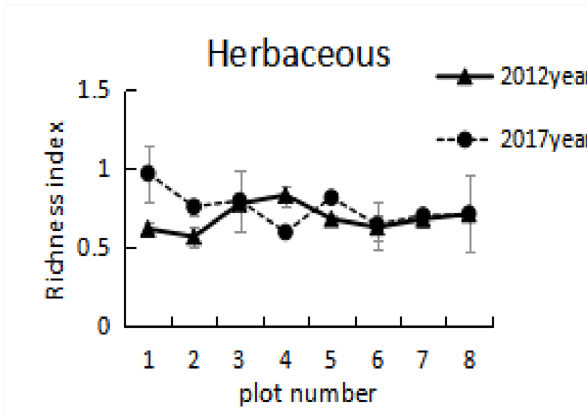

Figure 6. Two-year herbal richness

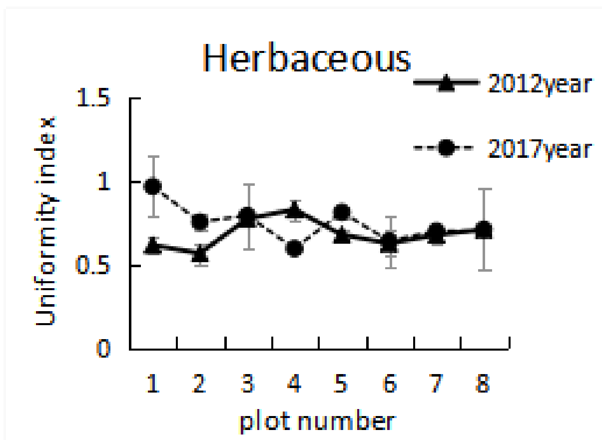

Figure 7. Two-year herb uniformity index comparison index comparison

Note: * At the significant level of 0.05, one-way ANOVA was performed.

2.3 Comparison of Biomass Values under Different Transformation Methods

From the following table (Table 2.), it can be concluded that the biomass of artificial regeneration in sample plot I decreased except litter layer, and the biomass of each layer in sample plot II increased significantly. The biomass of sample plot III decreased except litter layer, the biomass of each layer in sample plot IV decreased, the biomass of each layer in sample plot V decreased, and the biomass of each layer in sample plot VI increased. From the above, we can conclude that the biomass value of thinning intensity in the range of 30% to 40% is increasing annually, and the simple way of removing the ground cover can not effectively improve the biomass of undergrowth plants, and five years later, the value of litter layer is reversed. And bigger.

Table4 . Comparison of 2 years biomass under different transformation methods

Sample number	years	$t\cdot hm^{-2}$ Litter biomass	$t\cdot hm^{-2}$ Shrub layer biomass	$t\cdot hm^{-2}$ Herb layer biomass	$t\cdot hm^{-2}$ total
I	2012	2.8133	4.6211	0.4943	7.9287
	2017	6.4407	1.0041	0.3516	7.7963
II	2012	2.9659	1.3557	0.5678	4.8894
	2017	3.4119	3.5538	0.7082	7.6739
III	2012	3.3584	2.7813	1.1786	7.3183
	2017	3.3868	1.5188	0.5213	5.4268
IV	2012	4.1292	2.3636	1.0303	7.5231
	2017	3.3868	1.5188	0.5213	5.4268
V	2012	2.7567	1.8309	0.5998	5.1874
	2017	6.4094	2.0697	0.4956	8.9748
VI	2012	2.6643	2.2318	0.6030	5.4991
	2017	6.8243	2.3374	1.0035	10.1652
VII	2012	2.6856	2.4597	0.6113	5.7566
	2017	6.8243	2.3374	1.0035	10.1652
VIII	2012	2.6008	2.3407	0.9136	5.8551
	2017	8.5552	7.0843	0.5718	16.2113

3. Discussion

The effects of different management methods on plant species diversity, growth, development and regeneration of L. gmelinii forest are shrub layer: after different transformation methods, plant richness, growth uniformity and regeneration degree have been significantly improved. The biomass of shrub layer increased over 12 years, while that of herbaceous layer decreased. Because the tall Rhododendron in the upper layer blocked the sunshine, the growth of herbaceous under the forest was slow and the biomass was reduced. The transformation effect is in the order of I > II > V > III > VI > IV > VII.

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